Vol 3 #2

ENVIRONMENTAL QUARTERLY

COPY #2

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Case history of an altitude-temperature-humidity chamber

♦

Designing against shock and vibration

♦

Feasibility of Sand and dust testing to MIL-E-5272A

♦

In a future issue . . . a short history of environmental test equipment

Official publication of the
ENVIRONMENTAL EQUIPMENT INSTITUTE and the
INSTITUTE OF ENVIRONMENTAL ENGINEERS

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Vol. 3, No. 2 Second Quarter 1957

ENVIRONMENTAL QUARTERLY

Official Publication of the Environmental Equipment Institute and the Institute of Environmental Engineers

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The *Environmental Quarterly* is circulated to men concerned with environmental simulation and testing in industry, Government and our universities. It is the only magazine devoted exclusively to environmental science, simulation, and testing.

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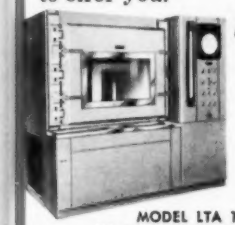

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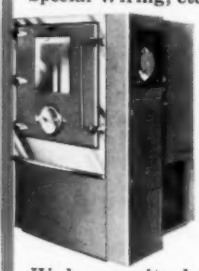

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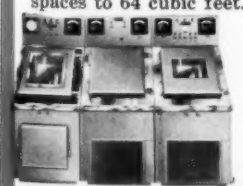

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THE GENERAL MANAGER SPEAKS . . .

As this issue of the Environmental Quarterly is going to press, the Headquarters office staff is working on the First Annual Technical Meeting of the Institute of Environmental Engineers. The flow of advance registrations indicates that this meeting will be attended by the largest number of environmental engineers ever to meet in one place. This is the crowning event of the annual program of the Institute, but it is not the only one. Already four active local groups have been formed. One of these has submitted its formal application for a charter as a local chapter. The others have held at least one technical meeting each, and expect to become fully accredited chapters before the fall programing begins.

In addition, we have received inquiries from all parts of the country expressing interest in local chapters and asking for help in getting them started. We confidently expect that before the 1958 Annual Meeting local chapters will be so widespread that most IEE members will be able to attend chapter meetings without extensive travel.

This fascinating growth invites reminiscence. Although this is the First Annual Meeting for the newly formed IEE, it is first in name only. This meeting is the direct descendant of a series of meetings started in 1955. At that time the present IEE was only an idea in the minds of the members of the Environmental Equipment Institute. Only a handful of men responded to their first invitation to affiliate with the "Science Section" of the Environmental Equipment Institute, but 170 attended the "First Annual Science Meeting." Several of those who attended were so impressed with the program that they decided to throw their lot with the initial handful. Out of this small number came the steering committee for the new organization.

All growth is slow at the start, and this group was no exception. The "Second Annual Science Meeting" found membership only slightly higher. But attendance at the meeting doubled. After that, things moved faster, and now the new engineering society is an established fact.

It is always a good thing to remember beginnings. In this case, as the new Institute moves on to greater activities, it is well to pay tribute to the vision of the manufacturers who provided the initial impetus, and to the few devoted engineers who have nurtured the organization during its formative period. The new Institute would not have been possible without the steady financial support of the Environmental Equipment Institute and the inspired efforts of the engineers who have guided it through its initial stages.

GEORGE D. WILKINSON
General Manager, IEE and EEI

REPLACING AN ENVIRONMENTAL CHAMBER

(A CASE HISTORY)

T. F. FOTI, The Glenn L. Martin Company

A Jinxed Chamber

If the old superstition about a ship being forevermore jinxed by an accident during its launching is extended to environmental test chambers, then a good example of such a jinx could be found here at the Martin Company.

In April, 1951, while a new altitude, temperature, and humidity chamber was being eased onto its site, it toppled over and tore the door off its hinges. Although the door was quickly repaired, from that day on the chamber seemed to be cursed.

As soon as tests were started, breakdowns of the chamber and its machinery began. The first year's breakdowns were usually of a minor nature such as clogged expansion valves, small refrigerant leaks, and blown gaskets. Although incessant maintenance was needed to keep the chamber operative, we felt that we were passing through a normal "shakedown" period that would soon end. However, during the second year of operation when major breakdowns resulted in as much "down" time as the minor breakdowns of the first year, we were forced to admit that the chamber was indeed jinxed.

When the manufacturer was queried about the cost of a new chamber that would utilize the existing machinery, he submitted a price that almost equalled the original cost, and would make no performance guarantees. The Martin Maintenance Department then surveyed the chamber and submitted an estimate for its complete rebuilding; this estimate was rejected for economic and other reasons.

Meanwhile, demands for test time increased to such an extent that the chamber was scheduled 24 hours a day, 7 days a week. Maintenance men frequently spent as many hours a month working to keep the chamber operating as test specimens spent in the chamber. The number of tests that had to be re-run because the chamber had failed to simulate an altitude cycle or to maintain a specified low temperature for the required number of hours steadily increased. Engineers no longer called to ask if the chamber was available, they first inquired about its health and then asked if we thought it could possibly complete a 24 hour test in 48 hours or more.

MR. FOTI is Supervisor of the Central Environmental Laboratory of the Glenn L. Martin Company at Baltimore. During his nineteen years with Martin, he has had assignments as electronics packaging engineer and group engineer of the Electronics Model Shop. As Supervisor of the Environmental Lab for the last three years, Mr. Foti has been responsible for the expansion of this facility.

When new, the extremes of the chamber were −85°F to +185°F, 85,000 ft. altitude, and 20% to 95% ±5% relative humidity. During its years of service the low temperature limit had steadily risen as a result of leaky cold wall coils, and the altitude had dropped because of door gasket, fan bearing, and other leaks that kept one pinhole ahead of our maintenance men.

The unreliability of the chamber, its shrinking ranges, and new, more severe test requirements finally, in January, 1956, culminated in a decision to replace this $30,000 chamber.

The New Chamber

Specifications for a replacement chamber were written not only in the light of our experience but also with the intention of eliminating as many of the faults of the old chamber as possible. We wanted a chamber that would last for a minimum of 15 years with down time confined to normal maintenance, and an escape from the hovering specter of obsolescence. A 300-word preamble discussed, in general terms, quality, workmanship, design objectives, fastener selection, door operation, etc.

The first item actually specified was size. This called for an unobstructed working space 4½ feet wide by 6 feet deep by 7 feet high. Although the old chamber (3½ by 3½ by 6½ feet) was large enough for most electrical and electro-mechanical black-boxes, it was occasionally found to be too small to accomodate an entire system, and thus these larger systems had to be tested by halves. When the specifications for the new chamber were written, we felt that electronic systems would grow in size and complexity in the immediate future although, later on, as subminiaturizing became more prevalent, the size, if not the complexity, would be reduced.

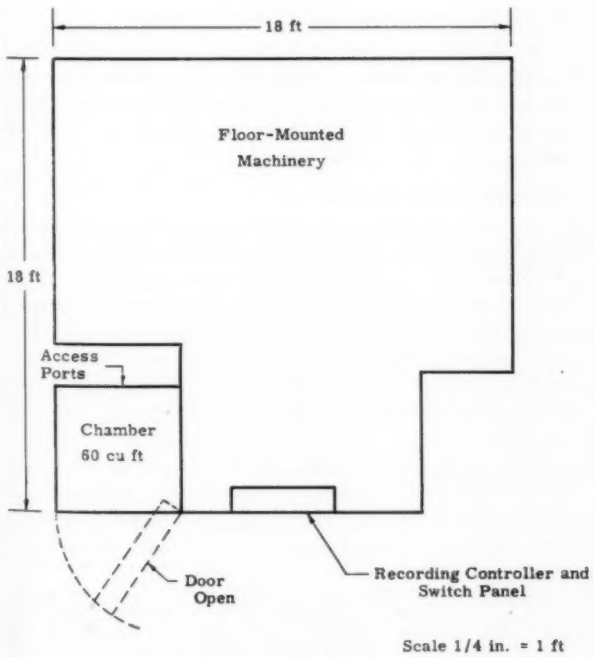
The rectangular plan specified will readily accommodate the general configuration of electronic chassis and systems as well as an occasional long narrow specimen that would be difficult to fit into a square chamber of the same volume. The width was increased from 4 to 4½ feet to facilitate the rapid installation and removal of an MB C 25H-B vibration exciter.

Construction Details

Construction details were heavily stressed because most of the major breakdowns of the old chamber occurred in the cabinet proper. The main purpose of the hard-board outer shell of the old cabinet was to hold the insulation in place. However, the inner shell served not only as a cold wall with integral tubing but also as a vacuum barrier. This inner shell, tack-welded to the grid-like supporting structure, flexed at the welds when altitude was simulated, and repeated flexings, particularly at low temperatures, gave rise to crystallization of the metal adjacent to the tack welds, causing irreparable refrigeration leaks in the integral tubing.

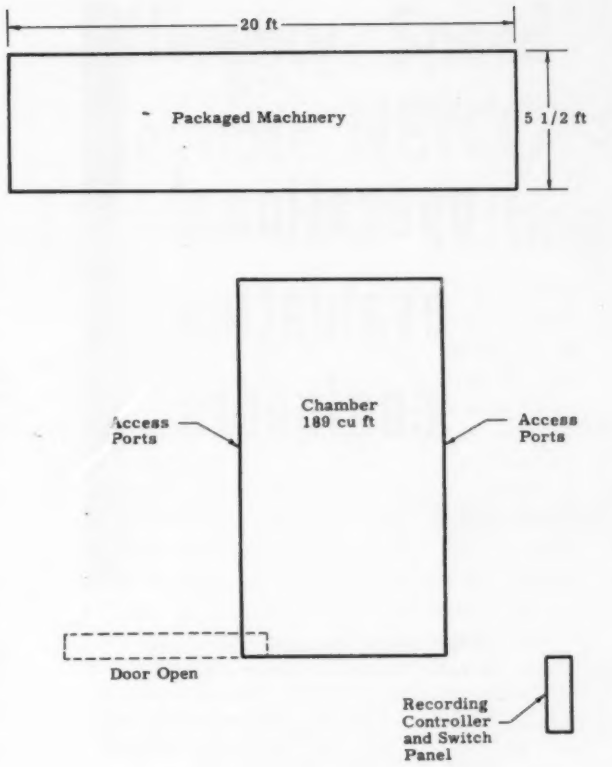
Criticisms of this type of construction are made only in the light of our experiences here at the Martin Company. We think that the old type of construction is probably quite satisfactory for smaller chambers, and, with improved design and welding techniques, would undoubtedly work equally well for large chambers.

After carefully considering the question of inner versus outer vacuum barriers, we discussed the question with various consultants. Since opinion strongly favored the outer barrier type for a chamber as large as our proposed A.T.H., a low cost proposal calling for an inner vacuum barrier was rejected in favor of a considerably higher-priced proposal specifying an outer barrier. This outer barrier will eliminate several tons of steel as a dead weight on the heating and refrigeration systems, a valuable factor when fast temperature changes and short stabilization periods are desired.



Scale 1/4 in. = 1 ft

Layout of the Old Chamber



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Layout of the New Chamber

We are, however, well aware that there are several disadvantages of this type of construction. For example, the space between the two shells must be evacuated at the same time as the testing area—which means that it will take longer to simulate a given altitude or that a faster evacuating system will have to be used. Also, since moisture will accumulate in the insulation area between the shells, a greater load will be placed upon the evacuation system.

Doors

Doors of altitude chambers are of necessity heavy and when shut must be hermetically sealed before air can be exhausted from the chamber. In the old chamber, the door was made of wood and was hung in the conventional way. Sealing was done by tightening hand-wheels, a time-consuming operation that became more difficult as humidity caused the wood to warp. For this reason, specifications for the new chamber called for the door to be power-actuated and tram-rail mounted. When open, it will expose a full 4½- by 7-foot entrance to the chamber. To facil-

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itate hermetic sealing when closed, compressed air cylinders will force the door against its mating surface.

Vibration Test Provisions

Conducting vibration tests in the old chamber was a laborious process. We decided to incorporate in the new chamber a means of installing and operating a vibration exciter internally as well as externally.

The ideal facility, from the standpoint of dynamics, would consist of an isolated seismic block around which the chamber could be built; however, the manufacturer would not accept this because of the heat load of such a massive block and the difficulty involved in sealing the chamber structure to it. Chamber manufacturers would have no problem if the users could safely place rubber isolators between the exciter and a conventional chamber floor. However, the knowledge that serious damage to equipment could result from chamber resonances caused us to reject this method.

The final solution was a compromise acceptable to all parties. As part of the chamber structure were four piers so installed that the bottom ends terminated on the inner surface of the outer shell. The upper ends of the piers terminate as cups that protrude slightly above the chamber floor and retain specially designed isolating springs. Steel webbing ties the piers together and a steel pad is welded to the underside of the chamber adjacent to the steel piers. This pad rests on a large seismic block flush with the laboratory floor. In theory, this compromise was acceptable, even though there is a possibility that it may not be possible to attain vibrations below 10 cps. To excite a specimen below 10 cps, it would be necessary to fix the exciter rigidly to the siesmic block. No practical, maintenance-free method of doing this has occurred to us.

To permit internal vibration testing with an external exciter, a teflon bellows-equipped penetration was specified for one side wall. Eye-bolts in the ceiling will permit test specimens to be suspended by pongee cord or steel cables.

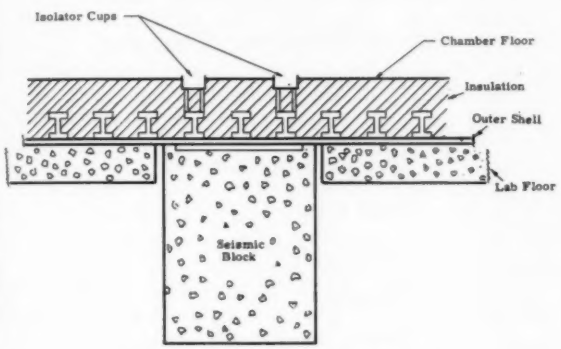
Environmental Limits

As a clearing-house for environmental information, the Martin laboratory has occasionally been asked if it could simulate altitudes as high as 300 miles and temperatures below −300°F or above 1200°F. Environmental equipment manufacturers have probably already built such chambers, but in view of the rare requests for extremes of this nature and the high cost of a facility capable of producing them, we decided upon more conventional extremes for the new chamber.

A low temperature limit of −120°F was specified, since some engineering data tests (as opposed to formal qualification tests) are now conducted at −100°F and we feel this low temperature requirement may, in the future, be made even more severe.

The Martin laboratory is presently equipped with four low temperature facilities. Two of these facilities have triple-stage Freon 22 systems, one has a parallel double stage Freon 22 system, and the fourth has a 13/22 cascade

system. Because we have had far less trouble with this last system than with the other three, a Freon 13/22 cascade refrigeration system was specified for the new chamber. We are inclined to attribute this lack of trouble to the high (25-inch) vacuum needed by Freon 22 to produce −100°F, while for this same temperature Freon 13 operates at a 7.5-pound back-pressure. Another reason for selecting the cascade system was its compactness. The sprawling parallel double-stage system of the old chamber was installed at a time when space was not a problem. However, with the addition of new test facilities, laboratory space has become increasingly scarce.



Internal Vibration Exciter Provisions

To determine the "live" heat loads that the chamber might be called upon to dissipate, projects were canvassed. To allow for growth as well as tolerance, we selected five KW as the top limit.

An upper temperature limit of 350°F was specified for the chamber heat source. This choice was made on the basis of economy (the chamber manufacturer indicated that to exceed 350°F would raise costs disproportionately) and a desire to simulate, probably by radiant heat, the high temperature environment induced by skin friction in super-sonic aircraft.

Since this facility will be used primarily to test electronics and electro-mechanical specimens, an electronics engineering group was asked to establish the altitude requirement. Based on a pressure-density curve, this group found that the most serious arc-over hazard occurred at around 140,000 feet. Allowing for a safety factor, we specified the altitude extreme as 150,000 feet. This altitude can be attained in 45 minutes, and the usual test altitudes can be attained in 10 or 15 minutes. The manufacturer was requested to stress the chamber for a full vacuum load, thus if it becomes necessary to extend the altitude extreme, we can do so by using a more efficient evacuating system.

A rotary vacuum pump was selected instead of a steam-jet system. We felt that the rotary pump's ability to attain a 50,000-foot altitude faster than the steam-jet system was an important advantage since most of our altitude tests

(Continued on Page 12)

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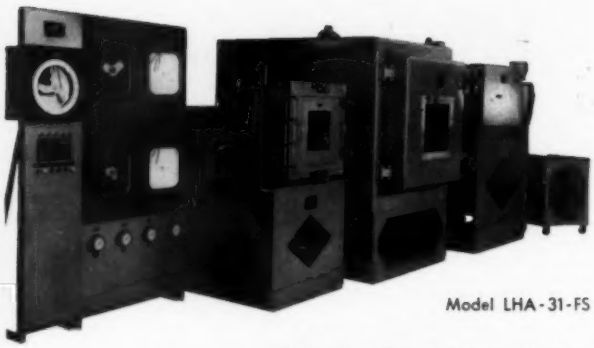

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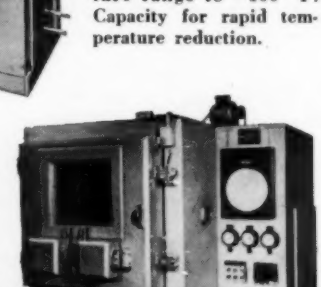

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SAND and DUST TESTING... in strict accordance with MIL-E-5272A is feasible!

BERNARD FRIEDMAN, Tenney Engineering, Inc.

There are few among the many people involved with sand and dust testing who would argue the statement, "It is almost the universal opinion of equipment users and manufacturers that sand and dust chambers do not perform in strict accordance with the military test specifications as they are ideally projected and put forth in Para. 4.11 of MIL-E-5272A."

Yet here, as in all phases of environmental testing, there is a pressing urgency for a "standard" in the light of which we can achieve minimum adequate performance in military components and materials. With the varying degrees of non-conformance with Para. 4.11 that exist in almost all present dust testing facilities, the environmental engineer is handicapped by being required to use a "rubber yardstick" which does not indicate the same measure in consecutive tests.

Awareness of this shortcoming of dust testing facilities has lead to a number of studies of sand and dust test specifications now being conducted by several Government groups concerned with the preparation of military environmental specifications.

This article is a report of a two-year development program from which has evolved a sand and dust chamber design whose performance conforms with the letter and intent of Para. 4.11 of MIL-E-5272A. Our program was based on a careful analysis of the requirements of Para. 4.11 as summarized in Table I, and of the known weaknesses that prevailed in existing dust treating facilities.

Basically, the marginal elements in each facility were one or more of the following:

1. Air circuit design to accommodate two levels of velocity prejudiced velocity gradients, that is, performance within velocity tolerances for each of the two wind-speed levels was marginal or questionable.
2. Marginal, inadequate, or uncertain control of relative humidity.
3. No provision for maintaining stability of dust composition.
4. Lack of specific purpose instrumentation to control and/or indicate dust density.

MR. FRIEDMAN is Chief Engineer at Tenney. He received his B.S. in mechanical engineering from Lehigh University. He serves on the Low Temperature Technical Committee of the Am. Soc. of Refrigeration Engineers, is a member of the Refrigeration Service Engineers Soc., and is an associate member of the Am. Soc. of Mechanical Engineers.

The rest of this article describes arrangements that were engineered, developed, and tested to give not only reliable trouble-free dust tests within the performance specifications of Para. 4.11, but were proven to be practical and capable of being repeated with excellent correlation of test results.

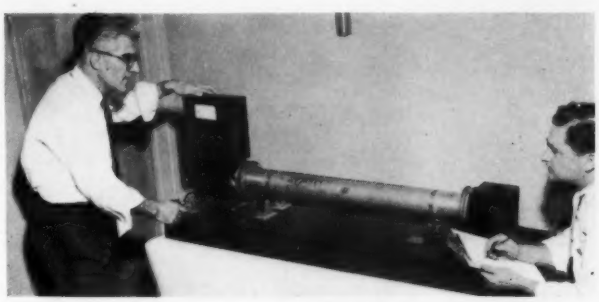

Figure 1. Density indicator controller being calibrated with standard calibration tube. Charles Lamb, project engineer, L., and his assistant, Harold Alstodt.

Control and Indication and/or Recording of Dust Density Level

In providing for instrumentation for indicating and maintaining dust density level, the basic criterion was to be the development of a reliable method for calibration, or a calibration standard. The obvious method of *sampling* a controlled volume, separating and weighing the dust, was looked upon as unreliable.

Assuming that a sufficiently small quantity of dust could be removed to make an accurate measurement, sampling is basically inaccurate, as well as being awkward and time-consuming.

In a typical dust chamber having a work space of 27 cubic feet and a volume of approximately 300 cubic feet, there is less than 3 ounces of dust in suspension throughout the entire chamber to attain a density level of 0.3 grams per cubic foot.

If a signicant quantity of dust were removed from the atmosphere for reasonably accurate measurement, there would be an equally significant difference of dust density at the start and finish of the sampling. This, of course, assumes that no dust is introduced during the sampling, since the introduction of additional dust would be uncontrolled in that one could not determine how much dust went into suspension and how much migrated to walls and crevices and did not go into circulation.

Here, in the reliability and accuracy of the dust density control, is the heart of the specification, and the true measure of a valid dust test chamber.

To achieve this, instruments were applied based on the idea of photoelectric measurement of dust density. This was felt to give the most promise in view of a calibration method conceived to supersede random sampling for instrument calibration. The inherent efficiency, reliability,

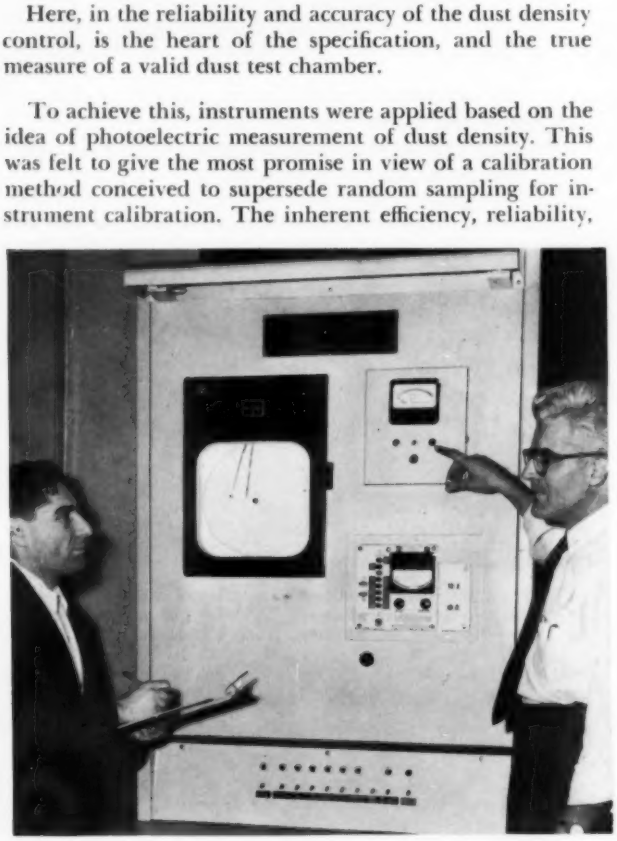

Figure 2. Sand and dust console control station showing temperature indicator controller, air velocity indicator, and dust density indicator controller. Charles Lamb, Project engineer, R., and Irving Isaacson, test engineer.

accuracy and repeatability of the calibration system that was evolved has made realistic dust density control a practicality.

Basically, the calibration is developed by use of "calibration tubes" containing a special suspension fluid for dust. The suspension fluid provides almost a "zero gravity atmosphere" for dust dispersion. Carefully measured quantities of dust, representing various dust densities, are introduced into the suspension fluid in each of the tubes.

The width of the tubes is identical to the scanned width of a chamber. At each end of the tube is a view port identical in construction to the chamber instrument view ports. A photoelectric light source and receiver element are placed at each view port. The tubes are mechanically r tated in a cradle between the stationary light source an receiver to provide uniform dispersion of the dust throug the fluid. The difference in photoelectric signal respons between the various tubes represents the increment change due to difference in calibrated dust density.

To our knowledge, and because of the success of thi calibration technique, this was the first time a propose dust density instrument could be validly evaluate (Figure 1).

There were significant and interesting results. The i strument, typical of those generally applied up to thi time, indicated dust density on a milliammeter whos scale was graduated in Ringelman counts. After extensiv zero and span scale adjustments, the best meter perfor ance is shown in Figure 3.

In cooperation with a leading manufacturer of photo electric instruments, an instrument was developed tha would give a typical curve in the calibration range a shown in Figure 4.

To develop this response, additional stages of amplifi cation were included in the electronic circuit, and a pr cise voltage regulator was applied for the light source an amplifier circuits to assure that calibration is unaffecte by external line voltage transients.

The resultant light source is of an extremely low inte sity infra red. The photoelectric receiver is uninfluence by variations of external light intensities because it attuned to the very low level infra red source.

The instrument circuits are arranged with calibratio zero and span tuning circuits, and a relay is supplied operate according to a built-in control circuit having ma ual set point for the specified scale. This relay operates dust feed mechanism. A dust storage and feed hopper applied, together with a mechanical dust feed assembl actuated by the dust density indicator controller.

Filters have been developed to reproduce the zero i fluence of the suspension fluid, plus increments of du density. By applying these filters in front of the light r ceiver when it is mounted on the chamber, light inte ference equivalent to calibrated dust density levels readily reproduced for accurate, fast, simple calibratio and/or recalibration.

Control and Indication of Relative Humidity

Almost all dust facilities that exist at this time a based on the design philosophy that the moisture is r moved from the recirculated air by presenting to the a flow a sufficiently low temperature surface to "freeze out the humidity from the air and dust.

This arrangement is marginal in that:

a. Basic chamber design limitations do not allo efficient removal of defrost water.

b. Dust of a composition in accordance with the MI specification is observed to have hygroscopic pro erties. When it is wetted, its handling, clingin and carrying properties are entirely different tha when dry. In addition to being inefficient, d

(Continued on Page 16)

NEW PRODUCTS

News of product developments are welcomed by the editor. Send releases to the *Environmental Quarterly*, 9 Spring Street, Princeton, N. J.

A new line of Variable Permeance Force Transducers are less affected by temperature changes than linear variable differential transformers or strain gages. Repeatability is nearly 100% and resolution is limited only by external circuitry. The transducer senses either compression or tension force without mechanical adjustment. Crescent Engineering and Research Co., El Monte, California.

Circle 22 on Reader Service Card.

Walk-In Test Room. Self-contained for operation of 30-200 F and 20-95% RH. Sizes from 4 x 4 x 7 ft. to 4 x 8 x 7 ft. Hudson Bay Co., Chicago 22.

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New Hydraulic Vibrator, Model F1557. 7" double amplitude, 15,000-lb. stalled-force machine. Maker claims proved 55 g at 600 cps unloaded. Random from 0 to 30 cps. Overall sinusoidal 0 to 550 cps. Made by Century Engineers, Inc., Burbank, Calif. under license from North American Aviation.

Circle 24 on Reader Service Card.

A self-balancing electronic potentiometer servo-mechanism is furnished by The Bristol Company of Waterbury, Conn., without a case, to be built into a user's equipment. Consists of standard Dynamaster instruments parts on a circular base, and with an indicating scale. Applications: Low-cost indicating pyrometer, resistance thermometer, or potentiometer; direct deflecting d-c milliammeter or millivoltmeter; self-balancing unit to operate analog-to-digital conversion mechanisms for readout.

Circle 26 on Reader Service Card.

Model 501-A differential pressure switch makes or breaks electrical circuits when differential equals or exceeds a predetermined value. Has low and high operating pressures of 250 and 500 psig and weighs 0.75-lb. Passes environmental test MIL-E-5272A. Gulton Industries Inc., Metuchen, N.J.

Circle 27 on Reader Service Card.

3-Oz. Accelerometer. Series LA03-0200 features an operating temperature ranging from −50° to + 100° C.; withstands vibration from 0 to 2,000 cps to 10g; shock-resistant to 40g. Humphrey, Inc., San Diego, Calif.

Circle 28 on Reader Service Card.

Pressure-Vacuum Control, type J95, for use in presence of explosive gases. Uncalibrated. Pressure settings made by internal adjusting nut. Adjustable ranges 0 to 500 psi, maximum pressures to 600 psi. On-off differentials between 2 and 30 psi obtainable. United Electric Controls Co., Watertown, Mass.

Circle 29 on Reader Service Card.

A wide-range thermistor radiometer for the remote measurement of temperatures permits relative or absolute readings from the still or moving surfaces of operating equipment, human or animal skin, building walls, and liquids. Sky and ground temperatures for environmental studies may also be determined. Measurement is based on the Stefan-Boltzman law for black-body radiation. Williamson Development Co., West Concord, Mass.

Circle 30 on Reader Service Card.

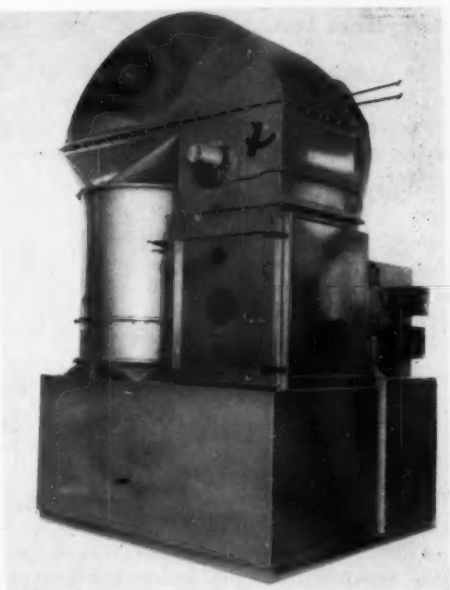
(Continued on Page 23)

NEW BOWSER

SAND AND DUST TEST CHAMBER

A SELF CONTAINED UNIT FOR CONDUCTING SAND AND DUST ATMOSPHERE TESTS UNDER SPEC. MIL-E-5272A.

Sand and dust chambers meet all MIL, JAN, USAF, AN, and other test specifications for aircraft and electronic components. Provide testing facilities in air-suspended sand and dust at air velocities of 200 and 2300 F.P.M. Accurate temperature control of air is provided by automatic heating and refrigeration equipment. Electronic density indication and control at .5 grams is a standard feature. 30% relative humidity is automatically maintained.



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REPLACING AN ENVIRONMENTAL CHAMBER

(Continued from Page 7)

are carried out at this altitude range. Furthermore, laboratory floor space is resticted and vacuum pumps occupy less space than steam systems. Other disadvantages of the steam-jet system are the noise it makes and its voracious appetite for steam and water. However, if future test requirements call for higher altitudes we will consider the steam-jet system.

The humidity facility of the old chamber was as elementary as a pot of water on a stove. The entire chamber floor (3½ by 3½ feet) formed a sump that was filled with ½ inch of water. Humidity was increased by turning on a series of electric strip heaters, located under the floor of the chamber, which heated the water. When the required humidity was reached, the heater current was turned off but the humidity continued because of the thermal lag, making precise control difficult if not impossible.

For the new chamber, we specified an external steam generator with automatic safety devices and which will maintain its own water level. Precise control will be possible with this design as well as maintenance-free operation.

A 12- by 24-inch rectangular port was specified for each side of the chamber. Adapter plates with hermetically sealed multi-pinned connectors will be made at Martin for these ports. We also specified two 5-inch diameter ports for each side of the chamber, and 22-inch square windows for the door and sides.

Minor chamber deficiencies were also taken into consideration. Two 150-watt vapor-proof lamp assemblies were called for as well as a drain large enough to carry off condensate and inadvertant spillage. The use of wood in any part of the chamber was specifically prohibited.

Acceptance Tests

In addition to these specifications, nine paragraphs of acceptance tests were spelled out. These tests, which will be performed as soon as the chamber is installed, indicated to the manufacturer the precise performance requirements.

Here is a typical test paragraph:

> "The refrigeration ability of the chamber shall be demonstrated by installing into the chamber a 5kw live load. While this load is being dissipated, the temperature of the chamber shall be reduced to −100°F in a period not to exceed 4 hours and then the altitude shall be raised to 70,000 ft. By means of thermocouple leads (which may be shielded against radiant heat) the temperature gradient between the inlet air and exhaust air shall not exceed 20°F for a 2 hour test period. At the conclusion of this two hour period, the load shall be turned off and a temperature of −120°F shall be attained and maintained for 2 hours."

There was no attempt on the part of the Martin Company to actually design the chamber however detailed the specification. Only items that had been found troublesome or deficient in previous laboratory experience were stressed, and the general intent of the specification was to tell what was wanted, not how to supply it.

	OLD CHAMBER	NEW CHAMBER
Working Space	60 cu ft	189 cu ft
Low Temperature	−85°F	−120°F
High Temperature	+185°F	+350°F
Altitude	85,000 ft.	150,000 ft.
Live Load Capability	No Figures	5 KW
Vibration Provisions	None	Internal & External Exciter
Relative Humidity	20 to 95% Internal Generator	20 to 95% External Generator

END

DEAN THERMO-PANEL COIL EXHIBITED ON WEST COAST

The Dean Thermo-Panel Coil was exhibited at the Western Metal Exposition in the Pan-Pacific Auditorium, Los Angeles, March 25 through 29. Dean Products, Inc., Brooklyn, N.Y., makers of the Thermo-Panel, is an associate member of the EEI. The Thermo-Panel Coil – which takes the place of pipe coils – was demonstrated to show how it applies to tanks, vats, reactors, mixers, valve warmers, etc.

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CERTIFIED TEST REPORTS

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THE ENVIRONMENTAL EQUIPMENT INSTITUTE

Founded September 1953

The Environmental Equipment Institute is a trade association of manufacturers of environmental test equipment, not to be confused with the Institute of Environmental Engineers. Here, briefly, is the story of the EEI, together with its present program.

Origin

Once a novelty, the testing equipment of the physical effects upon men, material, and equipment of changing conditions in the physical and man-made environment is now a serious and vital science, and environmental engineering is an established profession.

In response to the demand for equipment to make such testing possible under simulated conditions, a number of engineering concerns, during the period of defense preparation prior to World War II, began to devote their individual efforts to the design and manufacture of equipment to simulate the physical environment.

As the industry grew toward maturity the need increased for an organization to act as a clearing house for shared information which would make possible the solution of many common problems, and the establishment of standards for quality workmanship and performance of the equipment.

To meet this need, eight of the outstanding manufacturers in this field formed such an organization at a meeting held in New York City on September 23, 1953. The Institute of Environmental Manufacturers was the original name chosen for the organization. This name was later changed to the Environmental Equipment Institute.

Objectives

Among the objectives of the EEI, as outlined in its Charter, are:

To foster research and development aimed at advancing the knowledge of the physical characteristics of the environment.

To make available to manufacturers and users of environmental equipment scientific and technical data through publication of handbooks and periodicals.

To establish and mainstain standards of construction and performance for environmental equipment.

To extend the knowledge and techniques of environmental testing to related fields.

To establish and maintain ethical practices in the manufacture, sale, and servicing of environmental equipment.

To collect and distribute to its members data of interest to the industry.

Membership

Originally, the EEI embraced three classes of members: Manufacturing, Associate, and Science. The Science Section of the EEI was composed of individuals and companies whose interest lay primarily in the use of environmental equipment and in the advancement of the science of environmental simulation and testing. The Science Section grew so rapidly and became so dynamic that it was given full autonomy and became the Institute of Environmental Engineers, Inc., in the summer of 1956. (The *Environmental Quarterly*, fourth quarter 1956, published complete details regarding this new engineering society.) Today, the EEI consists only of Manufacturing and Associate Members.

Manufacturing Membership

Manufacturing membership is limited to companies actively engaged in the design, manufacture, and sale of environmental test and allied equipment. Because the industry is still in the development stage, the equipment cannot be closely specified. In general, manufacturers of equipment designed to reproduce the following environmental conditions are eligible:

Heat	Combustion
Cold	Explosion
Pressure	Gravity
Humidity	Radiation
Sand and dust	Corrosion
Vibration	Rain
Shock	Sunlight

This list is descriptive only, and any manufacturer interested in this class of membership in the EEI who believes his equipment to be environmental testing, even though the condition simulated is not in this list, should write to EEI headquarters for a decision. In addition to the type of equipment manufactured, certain other qualifications must be satisfied before a company can be admitted to manufacturing membership. Details will be supplied upon written request to EEI headquarters.

The present program of the Institute includes:

1. A monthly Confidential Bulletin containing a survey of the total dollar volume of business received by the industry.
2. A program for awarding an EEI Seal of Approval to manufacturing members whose products meet Institute standards.

(Continued on Page 22)

Designing for

VIBRATION and SHOCK RESISTANCE

T. M. BILLINGS, Bendix Aviation Corporation

In essence, vibration is a periodic motion that repeats itself, in all its peculiarities, after a definite length of time. Design Engineers are usually confronted with problems concerning vibrations that limit themselves to a relatively small space and that occur many times per second.

Vibrations are the result of oscillating forces. These oscillating forces can occur in rotating or reciprocating machinery, in the electrical disturbance of a magnetic field, in the immediate vicinity of high intensity noise sources, or within an elastic structure when shock forces are suddenly applied. Shock forces usually occur as transient vibrations resulting from a shock pulse, and such transients decay in an exponential function.

Vibrations experienced by equipment and instruments in our field of endeavor can be called harmonic (sine wave) in appearance. Mathematically, acceleration can be determined from vibrational motion as the second derivative of displacement with respect to time. Remember that one of the essentials of vibration is motion or displacement and the other criteria, by definition, is time. The calculation of accelerations in a sine-wave motion is a relatively simple thing. The complication is that most of the motion encountered by equipment experiencing vibration is harmonic in nature. However, for simplicity, the testing laboratory in most cases resorts to the use of acceleration-sensitive transducers for the measurement of peak-to-peak accelerations of harmonic wave-form vibrations.

Resonance and fatigue are the two greatest problems that arise when dynamic vibrations are encountered by equipment. These two problems are often difficult, if not impossible, to solve on paper, and thus dynamic testing furnishes the quickest and most economical answers where complex structures are the objects of concern.

Fatigue

Many structures or assemblies support the original static loads to which they are subjected. However, everyone is aware of the stories of "crystalized failures" as told by old-time garage mechanics which in reality are fatigue failures. Most of us have taken a piece of wire in our hands and bent it back and forth until it came apart. What we have done is vibrate the wire at relatively low frequencies until the stresses at the bending point fatigue the wire beyond its endurance. Essentially, vibrational testing is the most economical means of determining fatigue failures in materials. Such testing is merely the application of the same load over and over again. In this connection, I might say that not all vibration in an engine is damaging. A typical example of parts or components of an engine which are subject to vibration are the valve springs. They can take this treatment almost indefinitely without failure because no excessive stresses are permitted to occur.

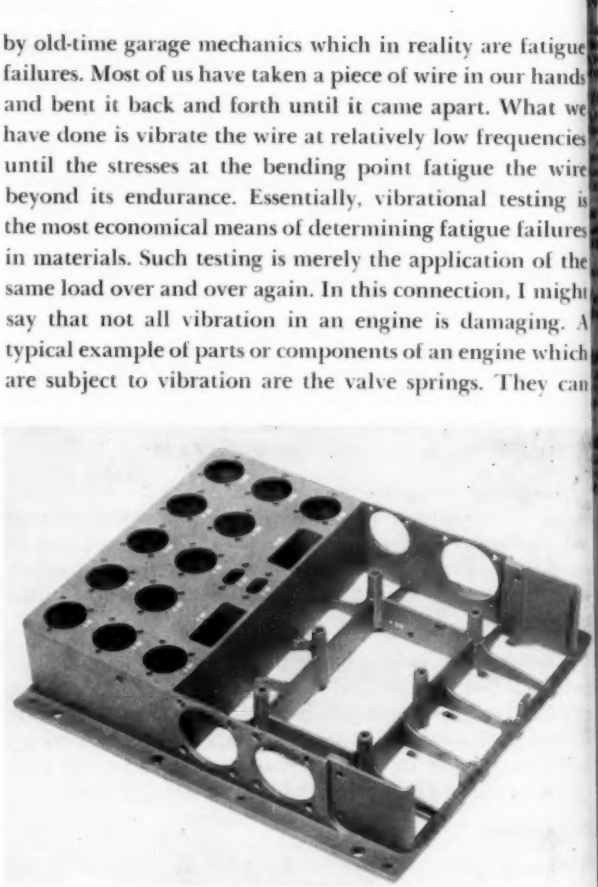

Figure 1. Example of a cast chassis utilizing ribs and tie-down points to which electrical components are mounted.

Resonance

Motion is the most noticeable effect of resonance vibration, which in turn results in high stresses of materials and possible malfunction of electronic apparatus. There are several ways to determine resonance in structures and equipment, and as you would surmise, dynamic testing is the quickest and most accurate. We must remember, how-

(Continued on Page 18)

Mr. Billings is Supervisor of Environmental Tests at the Kansas City Division of Bendix Aviation Corporation, where he has been since 1950. In 1949, he received the B. S. degree in mechanical engineering from the University of Kansas.

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SAND AND DUST TESTING

(Continued from Page 10)

humidifying by freezing is found to be ineffective in dehydrating dust that has been wetted by moisture absorbed from the atmosphere and by condensate from the defrosting dehumidifying coil.

The arrangement developed to preclude these factors is one in which there is a calibrated flow of dehumidified make-up air introduced into the suction of the blower. This incoming air is cooled to +35° F. by an extended surface heat exchanger and reheated to the controlled temperature by mixing with the recirculated air as it is passing through a temperature conditioner. There is an exhaust port built into the discharge suction of the blower.

This arrangement provides the following advantages:

a. There is positive, dynamic control of dehumidification by control of dewpoint of make-up air.

b. Relative humidity may readily be determined by reading "dewpoint" temperature of make-up air.

c. By providing pressure equalization at the suction of the blower, there is assurance that the static pressure throughout the rest of the air circuit is greater than room pressure. Thus, humid room air cannot enter the chamber to prejudice the controlled relative humidity. All leakage must be outward.

d. There is resultant rapid and positive "Percentage Purge," or partial exhaust, of recirculated air. Within a short interval after starting, make-up air

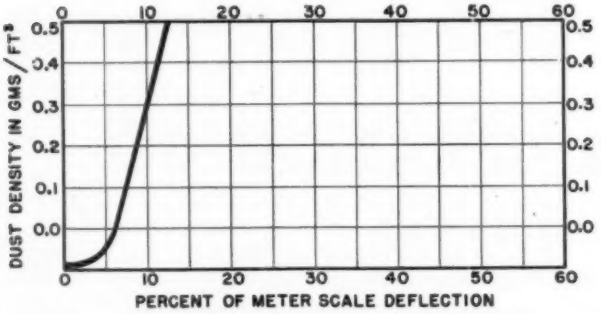

Figure 3. Photo-electric instrument response (as supplied).

is introduced in an amount equal to two or three times the volume of the chamber. The uncontrolled ambient air which existed within the chamber during a period of standby or while the test specimen was being set up is replaced with air containing dehydrated dust of controlled composition.

Control of Dust Composition

Para. 4.11.1 gives specific limitations on dust particle size and chemical composition. (See Table I, Item 1.)

When dehydrated dust, whose composition is in accordance with the requiremtnts of Para. 4.11.1 is introduced into a chamber to recirculate continuously for the duration of a test, there invariably occurs a change in its color

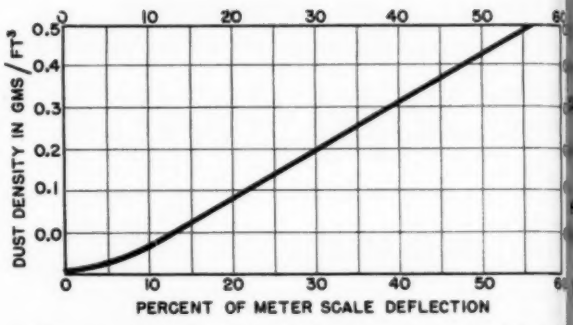

Figure 4. Photo-electric instrument response (as modified).

and texture. The dust is of an abrasive nature and acts to "polish" the walls of the chamber and the surfaces of the test item. Even if one could accept the contamination developed during a test, the contaminants, by virtue of color, reflectivity and electrical capacitance, have contributed in large measure to the lack of reliability of applications of most presently applied dust density and controlling instrumentation.

Close scrutiny of typical chamber configuration will confirm that it is impractical to remove and recharge dust from all portions of the chamber after each test. The arrangement for continuous "Percentage Purge" and controlled make-up of dehydrated dust is a positive answer to the need for maintaining stability of chemical composition and particle size of the dust.

Air Circuit Design for Optimum Tolerances of Velocity Gradient

The air mover was selected to be a slow speed, heavy duty, industrial type centrifugal blower, having inherent non-overloading, abrasion resistant, dynamically balanced backward curved blades, to give reliable, continuous performance.

The ducts of the air circuit were developed with radii ells containing appropriate baffles for uniform air flow. Normally, the approach duct length for attaining uniform air velocity distribution is a function of the Reynolds number. This length for straightening may be equivalent to 20 or more duct diameters for a normal size chamber. Because of prevailing space and height limitations, this arrangement is not deemed practical. An assembly termed "Strait-Air-Pak" was developed, which gives, in a short length, a straightening effect equivalent to that of extended duct lengths.

For high air speeds, the air circuit is arranged for air speeds in all the ducts to be greater than 1800 feet per minute, a value deemed to be the minimum optimum "carrying" velocity for dust.

For low air speeds, the required portion of the circulated air passes vertically downward through the designated test space while, for the remainder of the air, a damper introduces a bypass duct upstream of the "test space." A set of "choke" baffles is introduced immediately

(Continued on Page 20)

— CALENDAR —

MAY

Committee C-20 on Acoustical Materials, Am. Soc. for Testing Materials, ASA HQ: New York, N.Y. Write Fred F. Van Atta, Asst. Sec., ASTM, 1916 Race St., Philadelphia 3.

9-11 Fluid Control Institute, Inc. The Greenbriar, White Sulphur Springs, W. Va. Write Fluid Control Inst., P.O. Box 191, Decatur, Ill.

14-16 Second Annual Industrial Nuclear Technology Conf. Museum of Science and Industry, Chicago. Write Dr. Leonard Reiffel, Armour Res. Foundation, 10 W. 35 St., Chicago 16.

20-22 National Assoc. of Corrosion Engineers, NE region corrosion control conf. Syracuse Univ., Syracuse, N.Y. NACE HQ: 1061 M & M Bldg., Houston 2, Tex.

20-23 Design Engineering Show. Coliseum, New York. Second Annual Design Conf., in conjunction with the show, sponsored by Machine Design Div., ASME. Management: Clapp & Poliak, Inc., 341 Madison Ave., New York City 17.

27 New York Metropolitan Chapter, IEE, Environmental Science Workshop. Submit questions to Norman Meyers, Stratos Div., Fairchild Corp., Bay Shore, L.I., N.Y.

JUNE

2-5 Am. Soc. of Refrigerating Engineers, Annual Meeting. Hotel Fontainebleau, Miami Beach. ASRE HQ: 234 Fifth Ave., New York.

6-8 Annual Meeting, Nat'l Soc. of Prof. Engrs, Statler-Hilton, Dallas, Tex. Write NSPE, 2029 K St., NW, Washington 6, D.C.

9-14 3d Annual Automation Seminar, Penn State Univ., Univ. Park, Penna. Write Chester Linsky, Asst. Prof. Industrial Engineering.

12-14 Opns Research Conf. sponsored by Ill. Inst. of Tech. Write IIT, W. 33rd St., Chicago 16.

13-15 3d Nat'l Symp. on Instrumental Methods of Analysis at Univ. of Chicago. Sponsored by ISA. Write Herbert S. Kindler, Dir. of Tech. Programs, ISA, 313 Sixth Ave., Pittsburgh 22.

16-21 Am. Soc. for Testing Materials. Chalfonte-Haddon Hall, Atlantic City. Write ASTM, 1916 Race St., Philadelphia 3.

17-19 IRE Group on Military Electronics. Sheraton Park Hotel, Washington, D.C. Write R. E. Frazier, Cornell Aeronautical Lab., P.O. Box 235, Buffalo 21.

17-21 Annual Meeting of Am. Soc. for Testing Materials in Atlantic City. Write ASTM, 1916 Race St., Philadelphia 3.

24-27 Am. Soc. of Heating and Air-Conditioning Engrs., semi-annual meeting. Manoir Richelieu, Murray Bay, Quebec. Write A. V. Hutchinson, exec. sec., ASHAE, 62 Worth St., New York City 13.

We apologize to Herbert J. Saunders for having inadvertently omitted his name from our previous listing of IEE members. Mr. Saunders joined the IEE many months ago. New Members are listed on page 15.

—*Ed.*

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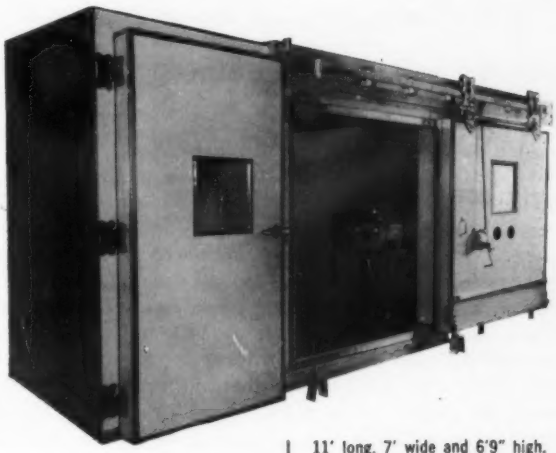

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VIBRATION AND SHOCK

(Continued from Page 14)

ever, that design factors considered should be those that will greatly influence resonant frequency ranges. The natural, or resonant frequency of a structure can be found from knowing the stiffness, or spring rate (designated K), and the mass of the material. The formula is thus

$$fcps = \frac{1}{2\pi}\sqrt{\frac{K}{M}}$$

where K is in units of lbs./in. and $M = (\frac{W}{G})$ or weight in lbs.

divided by gravitational units in inches/sec. ^{2}. This means that the stiffer we make a structure, panel, or bulkhead, the higher the exciting or disturbance frequency must be before the test object experiences resonance. This relates to the well-established design principle of striving for high moments of inertia. A second look at the equation should caution against merely adding more material to the test object in order to gain stiffness. The addition of bulk material through the use of thicker panels also results in more mass being subjected to the exciting force – and this lowers the point of natural frequency for a system. Design ingenuity is called for in providing additional stiffness through the use of lockfoam sandwich construction, ribs, channels, braces, etc., that do not increase the weight to any great degree.

In the original design considerations for equipment that must function in an environment of vibrational forces, several rules-of-thumb can be followed to minimize operational malfunction. Three elements that go into good designing techniques are: chassis design, ruggedizing components, and the use of isolators.

All panels, shelves, and mounting decks of electronic equipment should be as stiff as possible without a great deal of mass being present. Items mounted atop the chassis should have as low a center of gravity as is possible to reduce rocking modes. Delicate items like tubes and relays should be mounted near the edge of a panel in order to pick up additional stiffness from corners and side panel sections. Rugged components that can withstand the gaff of higher dynamic loadings – resistors, for example – should be placed in the center of flexible panels. A point of caution, however: If a component is too heavy, it may aggravate a resonating panel when mounted in the center, and even higher excursions would occur because of the additional mass. Heavy transformers fall into this category.

At any one set frequency, such as a resonant point, the g accelerations encountered are directly proportional to the total excursion or displacement of the segment in motion. Thus it is easy to understand why a vacuum tube would be more likely to experience microphonics if mounted in the middle of a resonating panel than when mounted out near an edge area. The use of the mechanical fastener at tie down points can greatly reduce excessive amplitudes in the middle of flat area sections. Castings

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invariably are stiffer than sheet metal fabricated sections and consequently afford better chassis mounting systems (Fig. 1). These ideas are mentioned merely as steps in the right direction — not as infallible solutions to all chassis design problems of a vibrational nature.

In general, the preferable course is to strive for greater rigidity in panels rather than merely to shift the position of components, although a judicious combination may be desirable.

After a well designed chassis has been "created" by the design engineer, the next problem is the selection of components. After knowing what types of components are necessary in order for a piece of equipment to perform

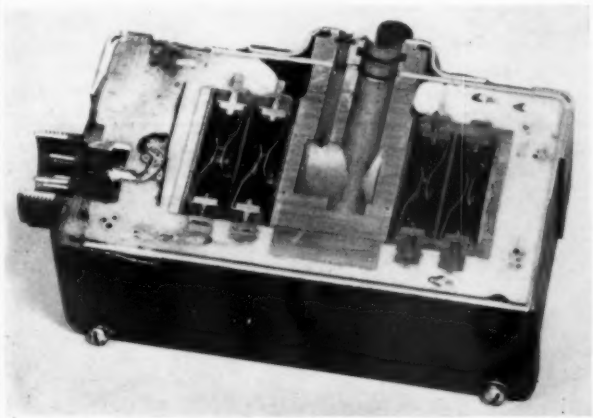

Figure 2. Use of foam type potting for a high degree of stiffness-to-mass ratio.

certain functions, the intrinsic design of each component should receive close scrutiny. Military requirements dictate that components be both rugged and reliable. However, component ruggedization does not mean making components elephantine in structure or sturdiness. Miniaturization or even subminiaturization of components is one way of avoiding vibrational troubles, for it must be remembered that forces exerted on chassis structures are directly proportional to accelerations encountered and mass weight. If it is impossible to eliminate or reduce vibrational accelerations, the forces exerted are lessened when sub-miniature components are used. Regardless of the size of a relay, if the coil section is not supported by the relay case, excessive movement will occur in the relay mechanism and wire fatigue or premature operation will be the result. Transformers also are components with many shortcomings. The mounting studs of a hermetically-sealed transformer should be attached to the core proper and not the can or container. The use of foam-type potting compounds is often satisfactory in adding sufficient stiffness to some "canned" components without increasing mass weight (Fig. 2).

(Continued on Page 22)

New Literature

News of literature of interest in the environmental field is welcomed by the editor. Send releases to the *Environmental Quarterly*, 9 Spring Street, Princeton, N. J.

Proceedings of 2nd Annual Meeting, Science Section, Environmental Equipment Institute (now the Institute of Environmental Engineers). Limited mimeographed edition being published in two volumes at $10.00 for both. Volume I is now available. Mailed automatically at no further cost to all who attended the Annual Meeting and to those who were members in good standing of the Science Section on or before April 20, 1956, but did not attend. Send orders to IEE, 9 Spring Street, Princeton, New Jersey.

Directory of Commercial and College Testing Laboratories, $1.00, published by the Am. Soc. for Testing Materials, 1916 Race St., Philadelphia 3. Supersedes Dept. of Commerce, NBS, Misc. Pub M 187. Lists labs that will test commodities for acceptance or for other purposes in accordance with standard specifications.

Fundamentals of spectrochemical analysis, including bibliography. 28 pp. First in a series of spectrochemical reference handbooks by Hilger & Watts Ltd., British instrument manufacturer, to be distributed in the U. S. by the Jarrell-Ash Co., Newtonville, Mass.

Circle 34 on Reader Service Card.

Atoms and Energy, by H. S. W. Massey. (1956) Philosophical Library, New York 16, N.Y. 174 pp. $4.75. An account of events in atomic physics leading to the release of atomic energy. Covers civilian and military applications.

National Standards in a Modern Economy. 372 pp. American Standards Association, 70 E. 45th St., New York. $5.00.

Journal of Solar Energy Science and Engineering. 64 pp. Assoc. for Applied Solar Energy, 3424 N. Central Ave., Phoenix. $3.00.

U. S. Dept. of Commerce Publications

Order from Office of Technical Services, using the PB number shown.

Development of Isolators for Heavy Airborne Electronic Equipment. L. C. Lindblom, The U. S. Rubber Co., for WADC. Mar. 1955, 36 pp. $1. PB 121317.

Survey of the Literature on Antioxidants and Anticorrosion Additives for Lubricants at Elevated Temperatures. J. W. Cole, Jr., A. Burger, and A. F. Benton, Univ. of Va. for WADC. May 1954. 830 pp. $10. PB 121726.

A Simple, Objective Test for Cable Noise Due to Shock, Vibration or Transient Pressures. T. A. Perls, NBS. May 1955. 24 pp. 75¢. PB 121583.

A Large Barium-Titanate Accelerometer for Shock-Velocity Measurements. T. A. Perls and C. W. Kissinger, NBS. June 1955. 19 pp. 50¢. PB 121584.

Research on Elevated Temperature Resistant Ceramic Structural Adhesives. R. M. Spriggs, H. G. Lefort, and D. G. Bennett, Univ. of Ill. for WADC. Sept. 1956. 99 pp. $2.50. PB 121659.

Investigation and Development of High-Temperature Structural Adhesives. A. S. Kidwell and K. L. McHugh, the Conn. Hard Rubber Co. for WADC. Sept. 1956. 75 pp. $2. PB 121657.

The Physical Environment of the Flyer. H. Haber, Air University, U. S. Air Force School of Aviation Medicine. 1954. 185 pp. $4.75. PB 121025.

Elements of Instrumentation: II. Temperature Transducers. K. S. Lion and W. L. Harries. MIT for Office of Naval Research. June 1955. 37 pp. $1. PB 121296.

(Continued on Page 23)

SAND AND DUST TESTING

(Continued from Page 16)

downstream of the "test space." At low air speeds, there is optimum carrying velocity throughout the air circuit except in the test space where the velocity is held to be uniformly within the specified range of 100 to 500 feet per minute by the application of the upstream "Strait-Air-Pak" and downstream "choke" baffles.

This arrangement, in conjunction with other features to be presented, has obviated the need for application of vibrators to the walls of the chamber to keep dust in circulation. The elimination of these vibrators, together with the application of a balanced slow speed blower, has drastically reduced the undesirable noise level that has been typical of many dust facilities.

Summary

This dust testing facility, incorporating new principles of humidity control, dust control, dust composition stabilization, and dust density measurement and control, represents a unique philosophy, and has demonstrated that sand and dust testing in strict accordance with MIL-E-5272A *is* feasible.

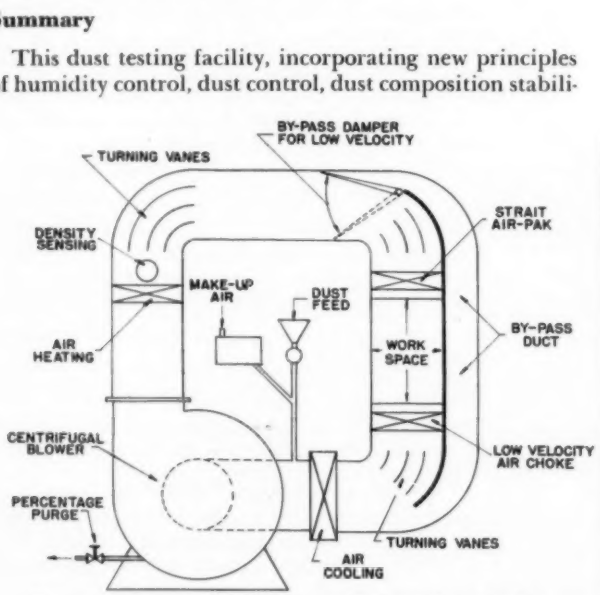

Figure 5. Schematic arrangement of dust-testing chamber.

TABLE I

1. *Sand and Dust Composition*
   a. 100 percent of the sand and dust shall pass through a 100-mesh screen, U S Standard Sieve Series.
   b. 98 ± 2 percent of the sand and dust shall pass through a 140-mesh screen, U S Standard Sieve Series.
   c. 90 ± 2 percent of the sand and dust shall pass through a 200-mesh screen, U S Standard Sieve Series.
   d. 75 ± 2 percent of the sand and dust shall pass through a 325-mesh screen, U S Standard Sieve Series.
   e. Chemical analysis of the dust shall be as follows:

Substance	*Percent by Weight*
SiO_2	97 to 99
Fe_2O_3	0 to 2
Al_2O_3	0 to 1
TiO_2	0 to 2
MgO	0 to 1
Ign Losses	0 to 2

2. *Temperature*
   a. +25° C. (+77° F.)
   b. +71° C. (+160° F.)
3. *Relative Humidity*
   Not to exceed 30 percent
4. *Velocity*
   a. 100 to 500 feet per minute
   b. 1800 to 2800 feet per minute

Ejector nozzles of high-altitude simulating equipment. Bank of three lowers pressure in barometric condensing tank. The photograph shows part of the jet vacuum equipment built by the Croll-Reynolds Company for the Fairchild Engine and Airplane Corporation. The equipment was designed to handle all of the exhaust from a 3,000 horse-power engine to achieve a simulated altitude of 50,000 feet.

IEE LOCAL CHAPTER NEWS

BALTIMORE—The latest group to begin the formation of a local chapter held its first meeting in Baltimore on March 27. Under the temporary leadership of Mr. Harold C. Jones, newly re-elected Vice President of the IEE, the proposed East Central Local Chapter came together for the first time to express their ideas regarding the proposed chapter and to listen to Mr. John Grimm, Wright Air Development Center, on "Environmental Criteria — Present and Future." Information presented by Mr. Grimm on probable future criteria was particularly well received by members of industry attending since this type of information is of great assistance in establishing requirements for procurement of long-delivery equipment. Mr. Grimm is Assistant Chief of the Environmental Criteria Branch. Mr. Jones is Senior Engineer, Environmental Test Section, Westinghouse Air Arm Division.

The meeting was attended by about forty persons from a widespread area ranging from Virginia to New Jersey. Plans are now in process for the formation of a vigorous steering committee to blue-print the formation of the local chapter and to operate the group until officers can be elected.

CHICAGO—Fifty persons attended the proposed Chicago Metropolitan Chapter on March 13 at the North Park Hotel to hear Mr. Paul Brandt, Chief Engineer, Murphy & Miller, Inc., present a paper on "High Altitude Missile Guidance Equipment Tested on the Ground." Mr. Brandt discussed the problems encountered in designing equipment and the application of instruments and controls to obtain altitudes of 120,000 feet and temperatures of 110° F below zero.

According to Mr. Henry F. Sander, newly re-elected President of the IEE, and sponsor of the proposed local chapter, a steering committee is to be formed as a result of this meeting for carrying the organization of the new group to completion.

The next meeting is to be held in May, Mr. Sander reported, at which time a paper will be presented dealing with some aspect of vibration testing. Notices of this meeting will be sent to the Midwest area early in May.

DETROIT—The first meeting of the proposed Detroit Local chapter was called to order on March 5th at 8 PM in the Vickers Service School Building by Mr. A. B. Billet, temporary chairman. Both Mr. Billet, of Vickers, Incorporated, and Mr. Charles E. Earl, President, Environmental Equipment Institute, described the history, organization, functions, and guiding principles of the IEE to the twenty-two persons in attendance, and explained the desirability of having a local chapter in the Detroit area.

The twenty-two persons present represented both the aircraft component and the automotive manufacturers in Detroit as well as one independent testing laboratory and one environmental equipment manufacturer.

"Special Problems of the Environmental Engineer" was the topic of the speaker of the evening, Mr. R. G. Yeager, Laboratory Staff Engineer for Chrysler Missile Operations. After a lively and informative Question-and-answer period, a steering committee was formed as follows: J. Reichert, Alpha Electric Refrigeration Co., R. G. Yeager, Carl C. Runyon, Ford Motor Company, Edwin F. Cape, Alpha Electric Refrigeration Co., and A. B. Billet. The next meeting was scheduled as a dinner meeting on April 9th.

NEW YORK CITY—The next meeting of the New York Metropolitan Chapter is to be in the form of an environmental science workshop designed to pose technical questions of general interest to a qualified panel. Members and other interested persons have been requested to submit questions and suggested topics for screening in advance of the meeting so that an appropriate panel can be selected. Chairman of the Technical Committee is Norman Meyers, Stratos Division, Fairchild Engine and Airplane Corporation, Bay Shore, L.I., N.Y.

The proposed New York Metropolitan Chapter is the first group to complete its organization, draft its by-laws, and make formal application for a charter under the national organization.

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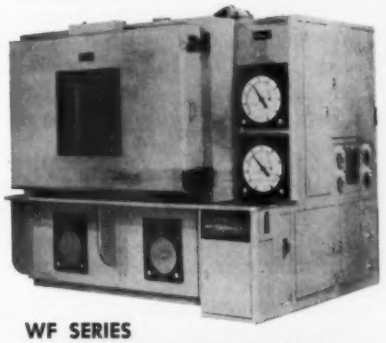

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VIBRATION AND SHOCK

(Continued from Page 19)

It is probably apparent to the reader by now that there is no magic formula for correcting design faults for vibration resistant equipment. No empirical formulas are available that will steer the design engineer about all the possible vibrational pitfalls and it is for this reason that an environmental test section is required. The final test for a designing job is seeing if it will withstand laboratory-simulated field conditions.

Vibration Isolators

Whenever original specifications limit the design engineer with regard to such aspects as weight, size, clearance, etc., so that vibration resistance cannot be built into the product, then measures must be taken to keep excessive vibrational forces from reaching the designed object. The "ace-in-the-hole" for the design engineer saddled with restrictions like this is the use of vibration isolators.

Before adding vibration isolators to a specific installation, consider the following elements:

(1) Exciting frequencies and excursions of supporting structures.

(2) Critical frequencies of equipment being isolated and excursions that isolated equipment can stand at these frequencies.

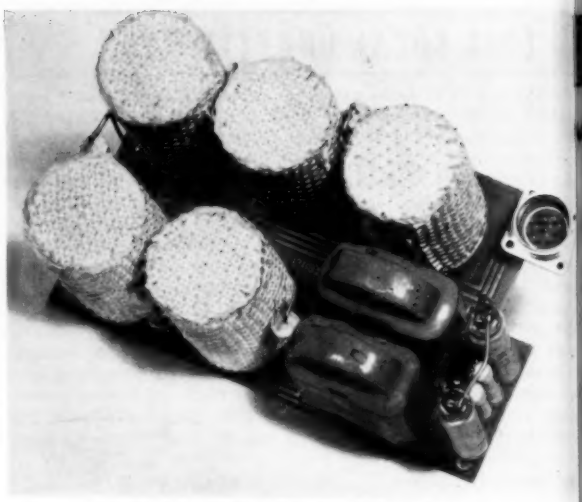

Figure 3. Typical electrical components prepared for foam type or plastic potting.

(3) Dimensions, weight, and location of center of gra ity (in all 3 planes).

(4) Space allowable for isolators and for equipme motion.

(5) Environment — ambient temperatures, corrosi atmospheres, etc.

(Continued on Page 24)

THE EEI

(Continued from Page 13)

3. The joint production of a Handbook of the Environment with the Institute of Environmental Engineers.
4. Joint publication of the *Environmental Quarterly* with the Institute of Environmental Engineers.
5. Sponsorship of an annual Environmental Equipment Conference, in conjunction with the Annual Technical Meeting of the IEE.
6. An active and continuous project for working out a code of trade practices in cooperation with the Federal Trade Commission.

Associate Membership

Associate Membership is open to companies engaged in the manufacture or supply of components and supplies used by manufacturers or operators of environmental test equipment who do not manufacture or assemble for sale any completed environmental equipment.

Associate members are entitled to send delegates to meetings of general interest of the Institute and to all special meetings to which they are invited by the Executive Committee. Delegates have the privilege of expressing their points of view but have no vote.

Associate members receive the publications of the Institute and in general derive the benefits of close association with the Manufacturing Members.

END

PERSONAL

Ralph L. Goetzenberger, vice president of Minn apolis-Honeywell Regulator Company, Washington, D.C has resigned, but remains as educational consultant.

Raymond J. Condon was promoted to divisional vi president in the Washington government-projects offi

Charles F. Woods has been appointed western sal manager for the company's Valve Division, with hea quarters in the Dallas office.

Minneapolis-Honeywell is an associate member of t EEI.

The Bristol Company, Waterbury, Conn., has appoint **John E. Kearns** manager of a new district sales office San Francisco. The Bristol Company is also an associ member of the EEI.

Electrical Testing Laboratories has announced the el tion of **Hoffman Stone Beagle** to the position of Pre dent. Mr. Beagle joined ETL as Assistant to the Preside in 1953 and became Executive Vice President in 19 ETL is a Company member of the Institute of Envir mental Engineers.

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Circle 14 on Reader Service Card.

NEW LITERATURE

(Continued from Page 19)

Performance of Stainless Steel Sandwich Construction at High Temperatures. V. C. Setterholm and E. W. Kuenzi. Forest Products Laboratory, Forest Service, U. S. Dept. of Ag. for WADC. Sept. 1956. 39 pp. $1. PB 121681.

Prevention of Mechanical Vibrations in Electronics Chassis — Design Manual. W. F. Stokey, C. F. Zorowski, and F. C. Appl, Carnegie Institute of Technology for Rome Air Development Center. Sept. 1955. 96 pp. $2.50. PB 121564.

A new free price list of Atomic Energy Commission unclassified research reports for sale by the OTS is now available. Request AEC Research Reports Price List No. 27, Washington 25, D. C.

Dean Bulletin No. 257 gives design and price information on the Dean Thermo-Panel Coil, which takes the place of pipe coils for industrial heating and cooling processes. Two plates are welded together after embossing. Embossed spaces form flow channels. Sizes, design characteristics, photographs, data. Do your own designing. Dean Products, Brooklyn, N.Y.

Circle 35 on Reader Service Card.

Calidyne Vibration Test Equipment. Six 2-page bulletins describe maker's Model 98 servo control (Bull. 98-56); Model 54 signal monitor (Bull. 54-56); Model 135 crossover servo control (Bull. 135-56); Model 142 frequency sweep cycler (Bull. 142-56); Models 174 and 177 "Wide Band" shakers (Bulls. 174-56 & 177-56). The Calidyne Co., Winchester, Mass.

Circle 36 on Reader Service Card.

Engineering News Letter, Vol. 1, No. 9, describes maker's steam jet heater. Schutte and Koerting Co., Bucks County, Penna.

Circle 37 on Reader Service Card.

General catalog reviews line of recording oscillographs, processors, amplifiers and power supplies, vibration measuring, pressure pickups, data processing systems, analytical and control instruments. Consolidated Electrodynamics Corp., Pasadena, Calif.

Circle 38 on Reader Service Card.

Titanium Buyer's Guides. How titanium is made, grade nomenclature, specifications, sponge, powder, sheet, strip, plate, bar, discs and rings, wire, extruded shapes, weight tables. Titanium Metals Corp. of America, 233 Broadway, New York 7.

NEW PRODUCTS

(Continued from Page 11)

Electronic cable is stable under temperatures from −85° to + 410° F. Hall-Scott, Inc., Berkeley, Calif.

Circle 31 on Reader Service Card.

Pneumatic solenoid valve controls air temperatures to 1000° F and air pressure to 4000 psi. Actuation time, less than .050 second; internal leakage negligible. Can be made for liquid oxygen and high temp. hydraulic applications. Sizes from ¼ to 2 inches and ½ inch AND tube size. 24 v DC.

Circle 32 on Reader Service Card.

A chilling machine for use in the sub-zero quenching of stainless steel has been developed by Cincinnati Sub-Zero Products, Cincinnati, Ohio. The newly designed Model 3SR-120-47 has a 47 cu. ft. chamber, and a net thermal capacity of approximately 6,000 BTU per hour at +120° F. Using convection fluid, it will chill 250 pounds of steel per hour from +80° to −120° F. It will accommodate typical missile or rocket stainless steel housing sheets of various gauges up to 10 ft. long by 3 ft. wide.

Circle 33 on Reader Service Card.

VIBRATION AND SHOCK

(Continued from Page 22)

(6) Stiffness of supporting structure.

(7) Characteristics of dynamic loading, that is, simusoidal, transient shock, or angular rocking, etc.

After a study of this information, the selection of appropriate vibration isolators becomes feasible.

In the selection of ready-made isolators with known vibration characteristics, it is best to select mounts with

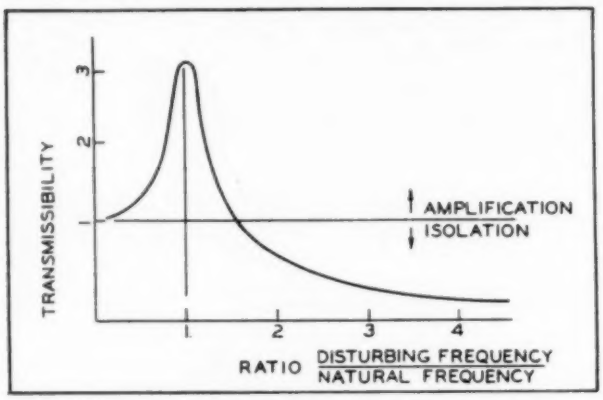

Figure 4

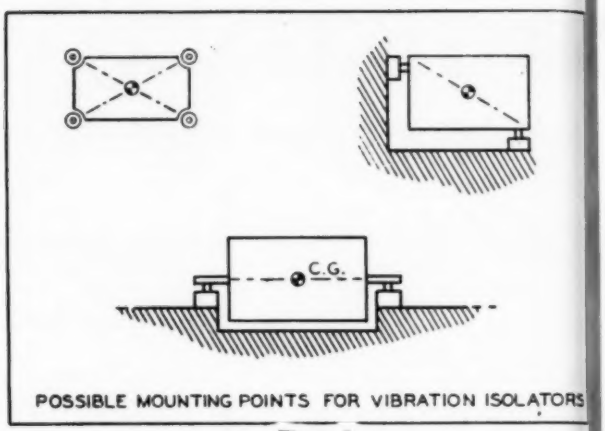

Figure 5

resonant frequencies well below the exciting or disturbing frequency (Fig. 4). Empirically thinking, the disturbing frequency of excitation encountered in the field should be two times the resonant frequency of the isolator system. To prevent the supporting structure from adding to the disturbance of excitation, it should have a natural frequency of 3 times the exciting or disturbing frequency.

The isolators should be attached so that an imaginary line connecting the isolator attachment points should pass

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through the center of gravity of the suspended object (Fig. 5). Often this is not feasible and rocking modes occur when the specimen is excited or subjected to vibrational loading. If the center of gravity of the item to be isolated is not near the geometric center of the structure, then load rates must be calculated in order for each isolator mount to carry an equal amount of the static load. When mounts carry different static loads on the same object, they must have different spring rates, that is, some will be stiff and some will be soft. Invariably, using mounts of different spring rates allows the phenomenon of rocking to occur and this usually results in having two different resonant frequencies. One resonant point causes the equipment to rock or revolve around the center of gravity and the second resonant point causes rocking about a point outside the enclosure of the equipment.

Damping

Because it limits the excursion or amplitude an isolated system will experience, damping is advantageous when a system is in resonance. However, after the system has passed through the resonant range, damping tends to increase transmissibilities which in turn renders poorer isolation. Some materials have inherent characteristics of providing damping that vary with deflections or loadings. Thus, it is possible to obtain high damping at resonance and less damping at higher frequency and lower excursions.

In general, it is desirable to have a minimum of 10 per cent of the critical damping present unless the resonant frequency never excited. Damping greater than 25 percent of critical can be obtained only by using elaborate dashpots or friction devices. Some resilient materials commonly used in isolator mounts, with their per cent damping values, are as follows: Steel springs — ½%; rubber — 2 to 5%; knitted wire mesh — 15%; felt — 6%; cork — 6%.

As the final proof of the pudding lies in the eating, so it is also with equipment designed for vibration resistance. Empirical formulas are helpful but not all-insuring and the final analysis of whether equipment is well-designed is how it functions in the field. The purpose of an environmental test section is to simulate anticipated environmental conditions and advise the necessary steps to remedy probable failures or malfunctions, whether it be design or production faults.

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IEE CONDUCTS FIRST NATIONAL ELECTIO

Dr. George D. Wilkinson, General Manager, IEE, ha announced the outcome of the first national election o the Institute, conducted by mail ballot during the thir days prior to April 1st, 1957.

The slate presented by the Official Nominating Com mittee were unanimously elected by the voting membe ship of the IEE. The new officers are as follows:

President, Henry F. Sander, Vapor Heating Corpora tion, Chicago, Ill.; Executive Vice-President, Roger Amorosi, Parameters, Inc., Garden City Park, N. Y.; Vic President, Fiscal Affairs, Harold C. Jones, Westinghou Air Arm Div., Baltimore, Md.; Vice-President, Local Cha ters, Arthur Billet, Vickers, Inc., Detroit, Mich.; Vic President, Publications, Cyril C. Campbell, Convair, Sa Diego, Calif.; Vice-President, Membership, Irving Polak, Marquardt Aircraft, Van Nuys, Calif.

The Nominating Committee was composed of Ralp W. Lisk, Wyeth Engineering, Inc., Chairman; Ted Fot The Glenn L. Martin Company; and Otto Altman, Lea Inc. There were no write-ins.

IEE ANNOUNCES PRIZES IN MEMBERSHIP DRIVE

The Executive Committee of the IEE has announced a policy of awarding annual memberships in connection with a national membership drive to be launched after the Technical Meeting in Chicago on April 25 and 26. Each local chapter is to receive one such free membership to be awarded by the chapter to the chapter member bringing in the most new members during a specified period.

A similar award is to be made available to IEE members at large not affiliated with a local chapter. Details will be sent in the near future to both local chapters and to individual IEE members.

RECEIVES SOCIETY OF WOMEN ENGINEERS AWARD

Mrs. Rebecca Hall Sparling, design specialist for Convair Division of General Dynamics Corporation, has received the 1957 Award of the Society of Women Engineers for significant contribution to engineering.

Mrs. Sparling, who directs materials research at Convair's Pomona, Calif., plant, is especially noted for her work in nondestructive testing, high temperature metallurgy, and gas turbine development.

In addition to her regular work for Convair, where she has been since 1951, Mrs. Sparling represents the Pomona plant on the Aircraft Research and Testing Committee of the Aircraft Industries Association.

NEW FACILITY TO SIMULATE AIR SPEEDS OF 10,000 MPH

A facility for testing aircraft and missiles in an airflow of 10,000 mph at 9,000° F for periods of time never before attained is being developed at Cornell Aeronautical Laboratory, Buffalo, N.Y. The facility will be able to operate at these extremes of speed and temperature for periods of 15 seconds or longer. Up to now the hypersonic air flow at such elevated temperatures could be produced for only a few thousandths of a second.

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Letters to the Editor

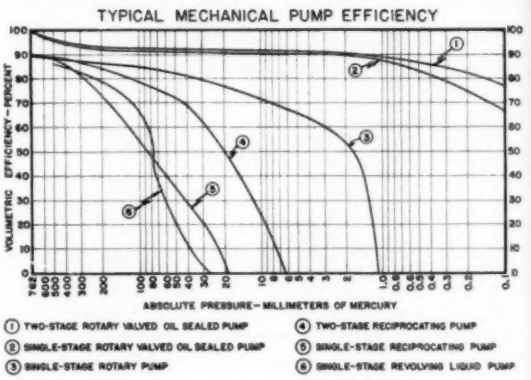
Dear Sir:

In Mr. Bykowski's article "Steam Jet Vacuum Pumping . . ." in the first quarter, 1957 issue of the Quarterly, he stated ". . . rotary pumps—sliding vane, lobe, and revolving liquid—are ordinarily limited to practical suction pressures equivalent to something in the order of 40,000 feet in single-stage operation and 70,000 feet in two-stage operation."

When authorities discuss the practicability of available equipment which is being used today to simulate altitude, they must not make the mistake of classifying rotary pumps in one category. This would put the practical limitations in the order of 140 millimeters for the single-stage, and 33 millimeters for the two-stage mechanical pumps.

On the enclosed illustration, we see the volumetric efficiencies of various types of mechanical pumps. As can be noted, there is a marked difference in the various types of mechanical pumps, and when 70,000' altitude is reached, the single or two-stage rotary oil seal valve pump is the mechanical pump capable of giving desired pump characteristics.

Today, equipment manufacturers have reached the stage where the air leakage rate into a chamber which is built for high altitude simulation can be kept to a minimum. It is feasible to design vacuum chambers to allow for pressurization and detection of structural leaks by use of electronic leak detectors which detect less than 1 part per million of escaping gas. Hermetic construction removes a good deal of the air load, making the job suitable for mechanical pumps to handle. It is basically an unsound practice today to try to build a system to operate at low pressures if the air leakage cannot be controlled.


TYPICAL MECHANICAL PUMP EFFICIENCY
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④ TWO-STAGE RECIPROCATING PUMP
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⑥ SINGLE-STAGE REVOLVING LIQUID PUMP

Single stage rotary oil seal valve pumps are being used for altitudes beyond 120,000 feet, and two-stage assemblies applied for altitudes through 200,000 feet.

Unless the chamber is of an extreme size, in the average environmental laboratory, the installation costs of mechanical pumps are less expensive than steam jets when consideration is given to wells or cooling towers for the condenser cooling water, for steam transmission lines, exhaust silencers, etc. The same applies for operating costs.

In addition, pump-down speed for mechanical pumps is significantly greater than for steam jets having the same leakage air handling capacities at high altitudes.

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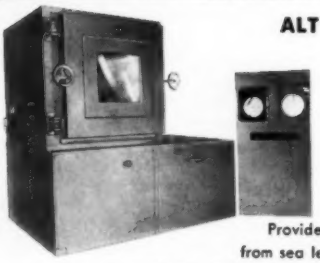

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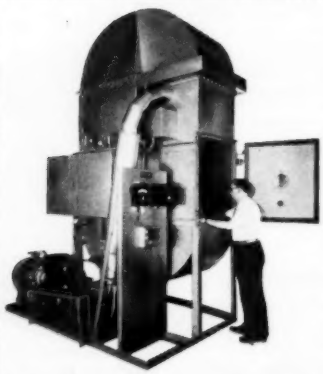

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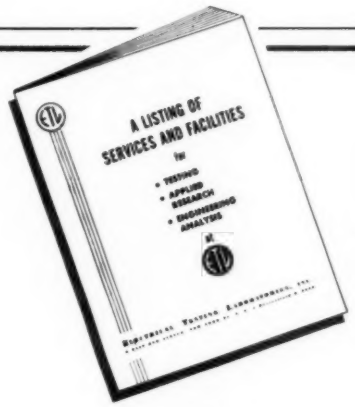

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RAIN:	4" per hour
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EXPLOSION:	Per MIL-E-5272A
FUNGUS:	Per MIL-E-5272A
SALT SPRAY:	Per MIL-E-5272A
SAND & DUST	Per MIL-E-5272A

All environmental equipment is suitably instrumented with recording, indicating and controlling devices and fully complies with the requirements of the Military Specification MIL-E-5272A.

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